EFFECTS OF DROUGHT ON STREAM DISCHARGE AND GROUND-WATER LEVELS NEAR LAKE SEMINOLE, SOUTHWESTERN GEORGIA AND NORTHWESTERN FLORIDA, OCTOBER 1999 – AUGUST 2000

Melinda S. Mosner

AUTHOR: [1/]Hydrologist, U.S. Geological Survey, 3039 Amwiler Road, Suite 130, Peachtree Business Center, Atlanta, GA 30360-2824
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Abstract. Stream discharge and ground-water levels were measured during Fall 1999, and Spring and Summer 2000, along selected stream reaches near Lake Seminole, southwestern Georgia–northwestern Florida. Baseflow was measured at 12 locations along Spring Creek, Fishpond Drain, and along the Flint, Chattahoochee, and Apalachicola Rivers and their tributaries. Ground-water levels were measured in 76 wells throughout the area surrounding Lake Seminole. Stream discharge and ground-water levels were highest in spring and lowest in summer; stream discharge in spring was almost four times greater than in summer. Although stream discharge and ground-water fluctuations during this period followed typical seasonal variations, continued drought conditions and ground-water pumping during the growing season limited the degree to which ground-water levels recovered during Winter and Spring 2000; as a result, less ground water contributed to the baseflow of streams than during normal conditions.

INTRODUCTION

Previous studies have shown a close hydraulic relation between ground-water and surface-water systems of the Dougherty Plain (Hicks and others, 1995; Torak and others, 1996). Under normal conditions, maximum amounts of ground water are discharged to streams during early spring when ground-water levels are highest. High evapotranspiration and heavy ground-water pumping during summer reduces rates of seepage into streams (Hicks and others, 1995). In June 1998, a severe drought exacerbated this relation, causing streamflows and ground-water levels at some locations to decline to record-low values. Average annual precipitation in the study area is 54 inches (The University of Georgia, 2000). From June 1998 through August 2000, a 27-month period, 95 inches of precipitation were recorded in southwest Georgia by the National Climatic Data Center, producing a precipitation deficit of nearly 27 inches. As a result, drought conditions reduced stream discharge in the study area to less than 12 percent of normal flow (U.S. Geological Survey, 2000).

Because ground water is the major water source for the region, and reduced surface-water flows may impact downstream users, a quantitative understanding of ground-water/surface-water relations is important for management of water resources in the Dougherty Plain area. In response to this need, the U.S Geological Survey, in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division, is conducting investigations of ground-water and surface-water relations in the vicinity of Lake Seminole in the southern part of the Apalachicola-Chattahoochee-Flint (ACF) River basin (fig. 1). This paper discusses stream-discharge and ground-water-level data collected during October 1999, April 2000, and August 2000, and relates these data to drought conditions.

Description of Study Area

Lake Seminole is a 37,600-acre reservoir formed in the mid-1950's with construction of Jim Woodruff Lock and Dam. The lake is located in southwestern Georgia at the confluence of the Flint and Chattahoochee Rivers and forms the headwaters of the Apalachicola River (fig. 1). The reservoir lies within the Dougherty Plain, a region of karst topography developed in the underlying Ocala and Suwanee Limestones. These limestones are the major geologic units that constitute the Upper Floridan aquifer, which is the principal ground-water source in the region. The thickness of the Upper Floridan aquifer ranges from just a few feet in the northern extent of the Dougherty Plain to more than 500 feet near Lake Seminole; aquifer productivity increases with thickness (Torak and others, 1996). Rivers in the ACF River basin are hydraulically connected to the Upper Floridan aquifer and the undifferentiated overburden. Near Lake Seminole, the Upper Floridan is thinly confined; where the aquifer is in close proximity to major streams, it commonly is breached, allowing

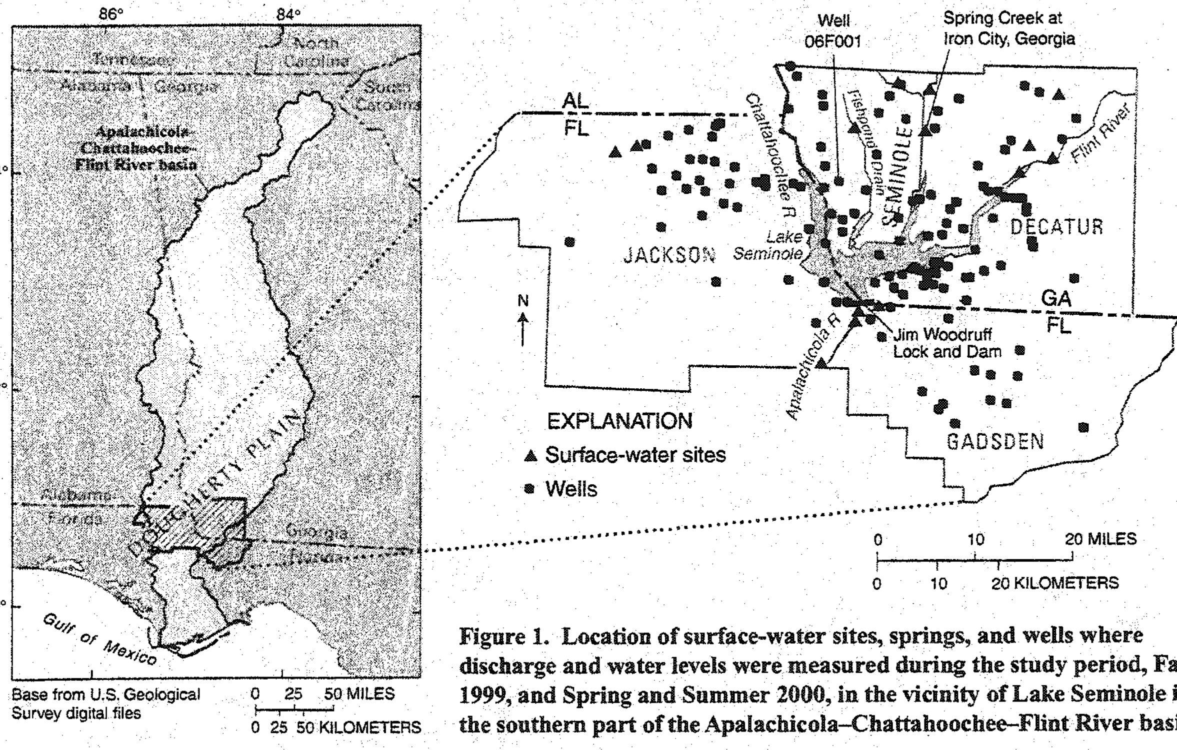

Figure 1. Location of surface-water sites, springs, and wells where discharge and water levels were measured during the study period, Fall 1999, and Spring and Summer 2000, in the vicinity of Lake Seminole in the southern part of the Apalachicola–Chattahoochee–Flint River basin.

flow between the stream and the ground-water system; thereby accelerating the dissolution of limestone and the development of springs (Torak and others, 1996).

Methods

Multiple discharge measurements were collected along selected stream reaches (fig. 1) during October 1999, April 2000, and August 2000 in the lower Apalachicola-Chattahoochee-Flint River basin using conventional methods, stream discharge and stage measurements, and acoustic Doppler current profiling. Ground-water discharge was measured at 17 springs upstream of Lake Seminole and south of Jim Woodruff Lock and Dam on the Apalachicola River. Water levels were measured in 76 wells in Georgia and Florida (fig. 1) using a steel tape. Net gains from or losses to the Upper Florida aquifer along selected stream reaches were calculated by subtracting upstream discharge measurements from downstream discharge measurements for each sampling period.

RESULTS

Three measurement periods were selected to characterize drought effects on seasonal low (October 1999) (fig. 2A), high (April 2000) (fig. 2B), and end of growing season (August 2000) (fig. 2C) ground-water and streamflow conditions. Annual ground-water highs typically occur during winter to late spring (February–April) and lows typically occur during summer and early fall (July–October), fluctuating by 20-30 feet yearly in response to precipitation and agricultural pumpage (fig. 3A). The hydrograph for well 06F001 (fig. 3A) shows typical annual water-level fluctuations during the years 1990-1997 preceding the drought, as the water level in the well recovers from ground-water pumping during the growing season. After the 1998 growing season, water levels recovered to only a fraction of previous years; water levels continue to decline as drought conditions affect water levels in the aquifer (fig. 3A).

Stream discharge generally is highest during winter and lowest during summer, following a pattern similar to the fluctuation of ground-water levels (fig. 3B). Typically, as water levels recover during fall and winter, ground water discharges to stream channels to become baseflow. The drought, however, suppressed the recovery of water levels in the aquifer, thereby reducing stream baseflow and resulting in a decrease of surface-water discharge. In October 1999, daily mean discharge at the gage at Spring Creek at Iron City, Ga., was comparable to the discharge measured in previous years (fig. 3B); however, flow generally increased to more than 2,000 cubic feet per second (ft^3/s) by spring. In April 2000, stream discharge at this gage was only 89 ft^3/s (fig. 2B), less than 10 percent of normal flow. By August 2000, the reach in the study area had gone dry—with less than 1 ft^3/s of discharge recorded at each gaging station in the study area (fig. 2C). Flows along the Flint River also are only a fraction of discharges recorded under normal conditions. In April 2000, discharge at the gage in Bainbridge was 4,520 ft^3/s (fig. 2B); from 1992-1997, discharge at this same gage generally was greater than 15,000 ft^3/s, three times the discharge during drought conditions.

The normal pool elevation for Lake Seminole is 77 feet above sea level; drought conditions caused lake levels to drop nearly 3 feet, to 74 feet above sea level. During previous years, ground-water levels fluctuated 20-30 feet; during the study period, however, water levels fluctuated only 10-15 feet, and often did not reach an elevation sufficient to contribute baseflow to streams near the lake. Potentiometric-surface maps of the Upper Floridan aquifer (fig. 4) show ground water flowed toward the impoundment arms of Lake Seminole during each sampling period, but also show little fluctuation in the magnitude or direction of flow between seasons. During all three sampling periods, ground-water elevations were essentially equal to lake level elevations north of the lake (fig. 4). Because ground-water levels are not recovering as they would under normal conditions, less ground water is discharging to streams, thus reducing flow to the impoundment arms. This is evident in Spring Creek where during October 1999 and August 2000, the northern portion of the reach was a losing reach (fig. 2A, 2C). Essentially, the stream channel lost water to the ground-water system; whereas under normal conditions or periods of typical seasonal flow (April 2000), the reach would have gained flow from ground-water discharge.

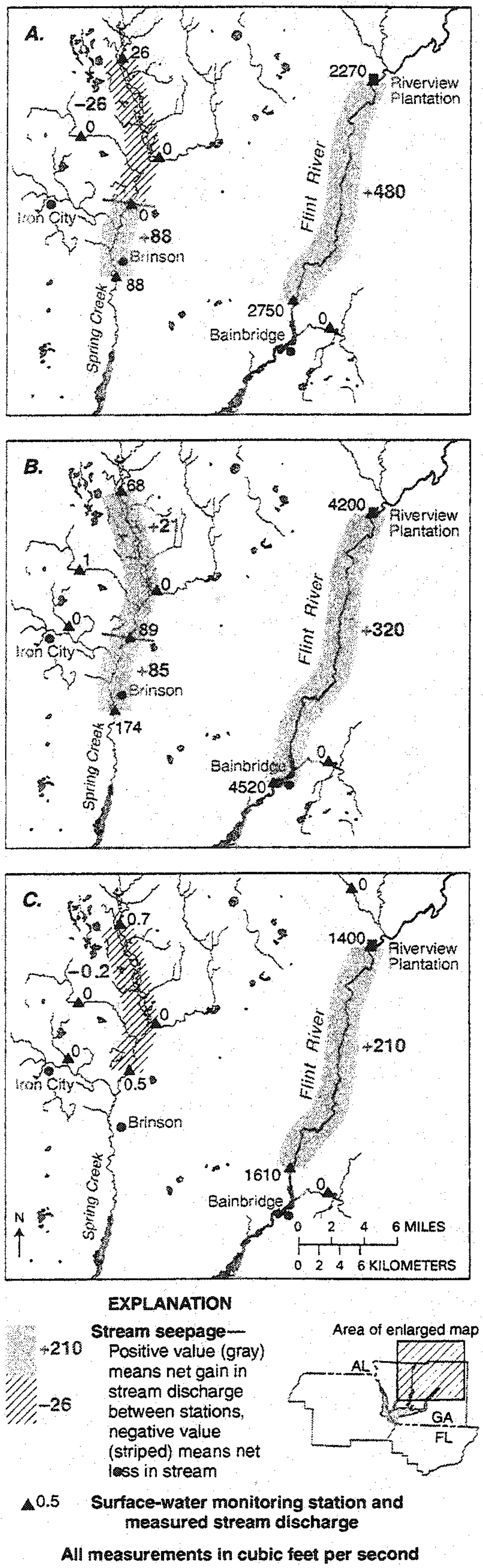

Figure 2. Stream seepage along the Flint River and Spring Creek reaches during *(A)* October 1999, *(B)* April 2000, and *(C)* August 2000.

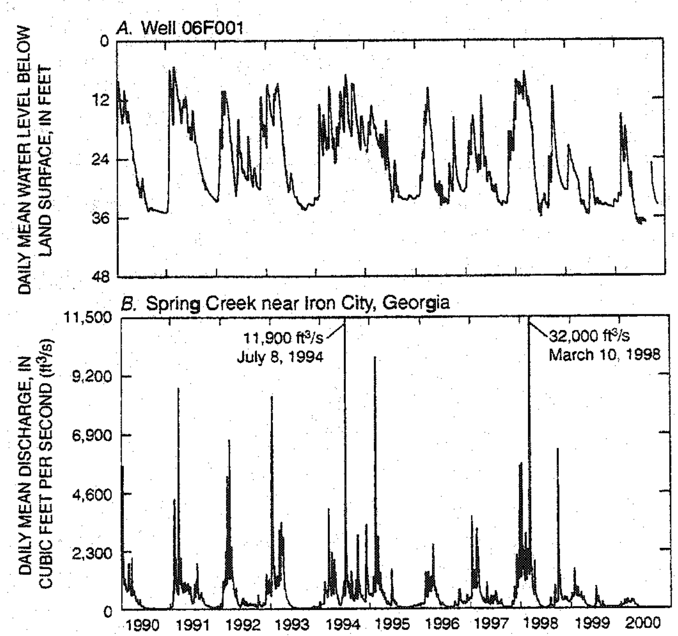

Figure 3. Hydrographs of daily mean *(A)* ground-water levels and *(B)* streamflow in the vicinity of Lake Seminole during Fall 1999, and Spring and Summer 2000.

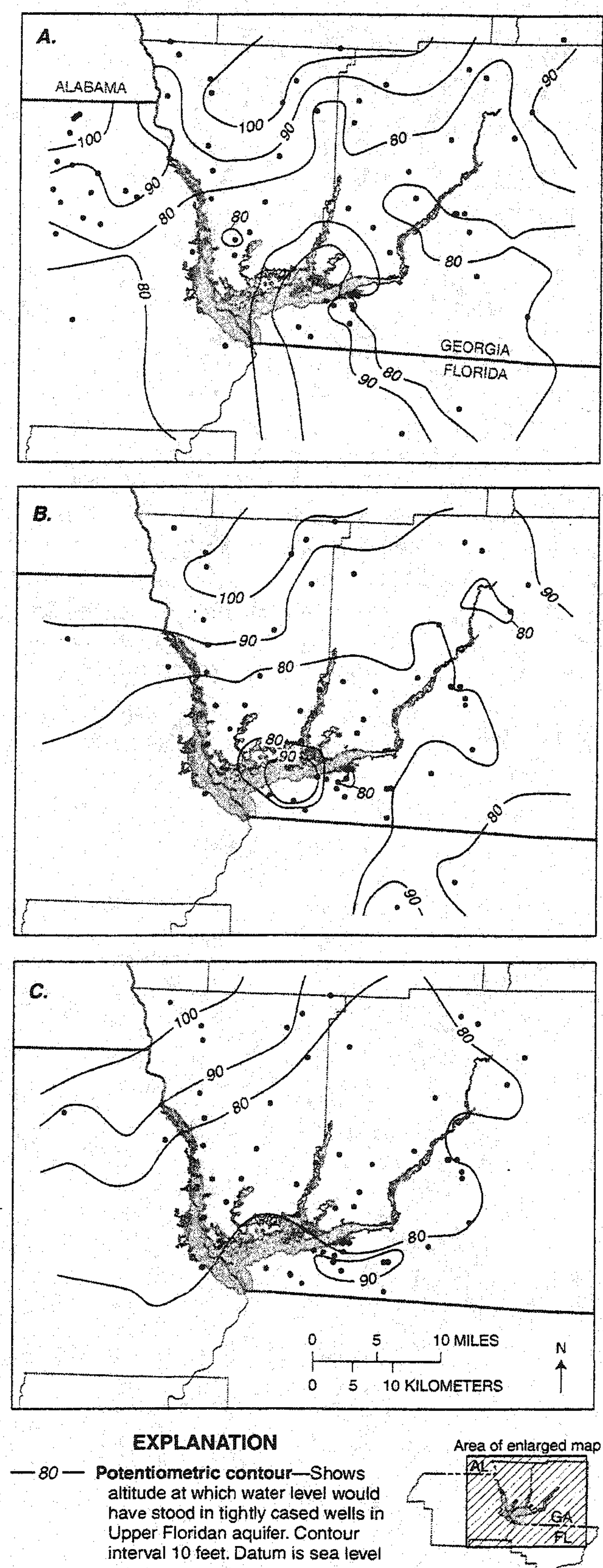

Figure 4. Potentiometric surfaces of the Upper Floridan aquifer during *(A)* October 1999, *(B)* April 2000, and *(C)* August 2000.

DISCUSSION

Although surface-water and ground-water conditions in the Lake Seminole area showed typical seasonal variations, with water levels declining in summer and early fall, and recovering in spring, drought conditions exacerbated the hydraulic relation between the ground-water and surface-water systems in the study area. Because the two systems are hydraulically connected, and therefore, interdependent, continuous monitoring of ground-water and surface-water conditions is necessary to delineate stream-aquifer relations, that can be used to effectively manage water resources in southwestern Georgia and adjacent states. Measurements collected during the three periods described in this paper provide a basis for developing this understanding and providing information needed to manage the area's water resources. Ongoing investigations of the water resources of the area are attempting to expand ground-water level and stream-discharge monitoring networks, to develop detailed hydrologic budgets, and to quantify stream–aquifer relations.

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